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March 9, 2015

Mr. Joel Lemke
Director
Department of Public Utilities and Transportation
City of Stevens Point
301 Bliss Avenue
Stevens Point, WI 54481

RE: Town of Hull Well Impact Claims

Dear Joel:

As per your request, I have reviewed the claims of impacts to private wells from the operation of City of Stevens Point Well 11 as described in a report from Montgomery Associates Resource Solutions (MARS) prepared for the Town of Hull dated October 9, 2014.

As you know, I attended a meeting with the Town of Hull (the Town) and their consultant on November 11 with Mr. Andrew Beveridge, the City Attorney for Stevens Point. The purpose of the meeting was for MARS to present their findings and deliver their report. As a follow up to that meeting you asked me to perform an independent review of the data and prepare a professional opinion of impact of pumping Well 11 on the private wells described in the MARS report. This letter summarizes the results of our analysis.

Well 11 is a horizontal collector well that began limited pumping for ten days in May, 2012 and began regular service in June, 2012. From June, 2012 to October, 2014, Well 11 pumped between 40 and 125 million gallons per month with an average daily pumpage of 2.8 million gallons per day (gpd). **Figure 1** shows the location of Well 11, the private wells that were replaced, and several monitoring wells in the sand and gravel aquifer installed by the City of Stevens Point (City monitoring wells) to monitor changes in groundwater levels in the aquifer.

The MARS report described 29 wells that were replaced from May 2012 to August 2014 due to capacity problems. Some of the wells were nearly a mile from Well 11. They reported that "Many of the replaced wells had bottom elevations near the water table". In our meeting with the Town in November, Town officials related that many of the wells were sand points driven a few feet below the water table. Wells of such construction can lose the capacity to produce water if the water table drops too close to the top of the sand point screen. In addition, plugging caused by natural mineral encrustation or biological growth can plug the point screens and cause additional drawdown within the well point that can cause the sand point to break suction and stop producing water.

As of 1991, WDNR required driven sand points to be completed to a depth of at least ten feet below the groundwater surface. If these wells were installed during periods of high groundwater, there would be only a few feet of water above the screens during periods of low groundwater levels. Many of these wells may predate the current well code, may have been installed by home owners or other people unfamiliar with the well code, and may have been installed less than ten feet below the groundwater surface. If they were not installed ten feet or more below the groundwater surface, they may be even more vulnerable to periods of low groundwater levels.

Figure 1: Location of Well 11, Replaced Wells, and City of Stevens Point Monitoring Wells (Source: MARS 10/9/14 Technical Memorandum to Town of Hull)

MARS used several methods to estimate the drawdown caused by Well 11. They postulated that Well 11 could have caused between 2.5 and 6.5 feet of drawdown at monitoring well MW3, located approximately 1,400 feet from Well 11. Our analysis of the data indicates that the actual drawdown of Well 11 is below the low end of their estimates at MW3.

There are many factors that affect groundwater levels, but the two primary factors are changes in the amount of recharge that reaches the groundwater system and the amount of water removed by pumping. The USGS maintains a number of groundwater monitoring wells to monitor the change in water levels over time. The data is generally used to identify changes in groundwater storage due to climatic factors or changes in pumping. **Figure 2** shows the location of Well 11 and the seven closest USGS monitoring wells that have data for the period in question.

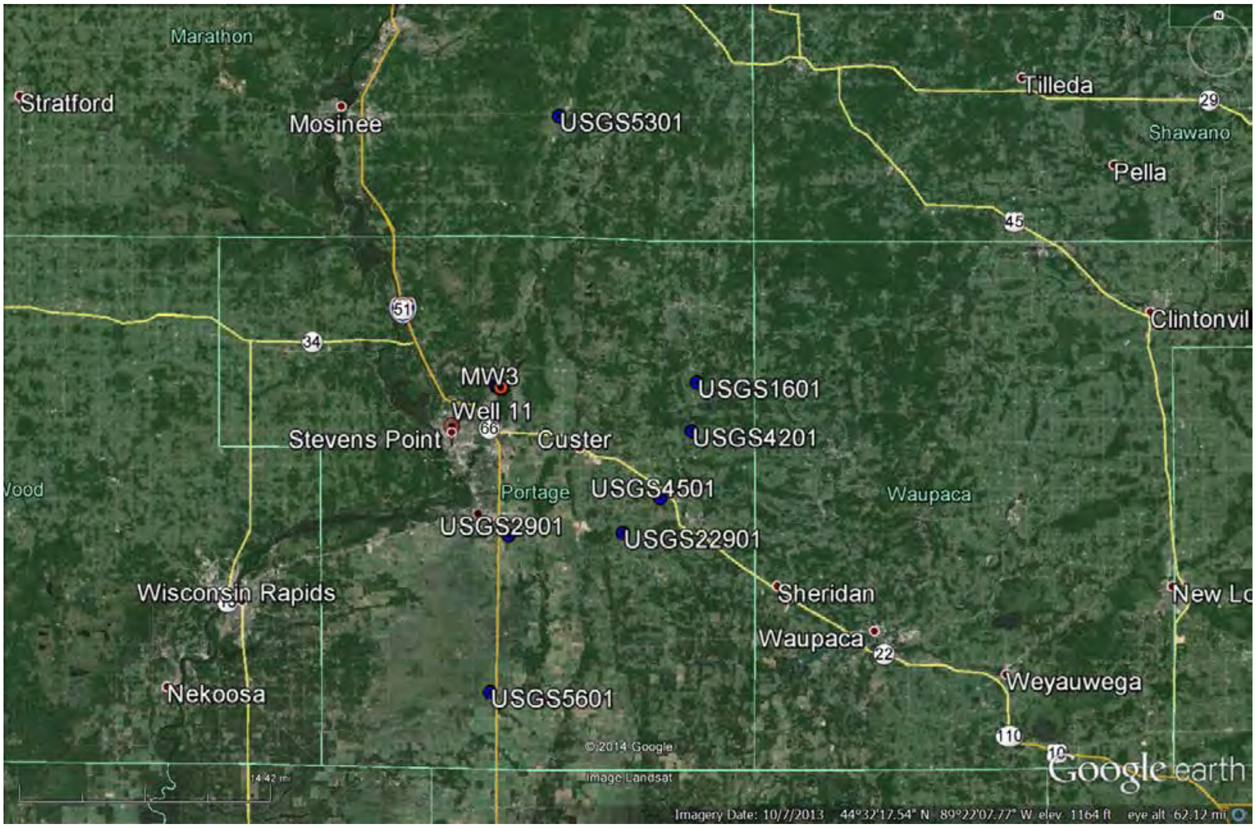


Figure 2. Location of USGS Monitoring Wells Near Stevens Point Well 11

Figure 3 is a plot of the depth to water for the seven USGS monitoring wells and City monitoring well MW3 for the period of record. The USGS wells lie about 7 to 15 miles from Well 11 and are located in areas with land use that ranges from predominantly forest to predominantly irrigated agriculture with some areas of mixed forest and agriculture. The USGS wells provide independent observations of groundwater levels that are miles beyond any potential impacts from Well 11 and reflect regional changes in groundwater storage. The data shows that water levels in the aquifer on a regional basis naturally vary by several feet in response to seasonal and annual changes in recharge and regional pumping.

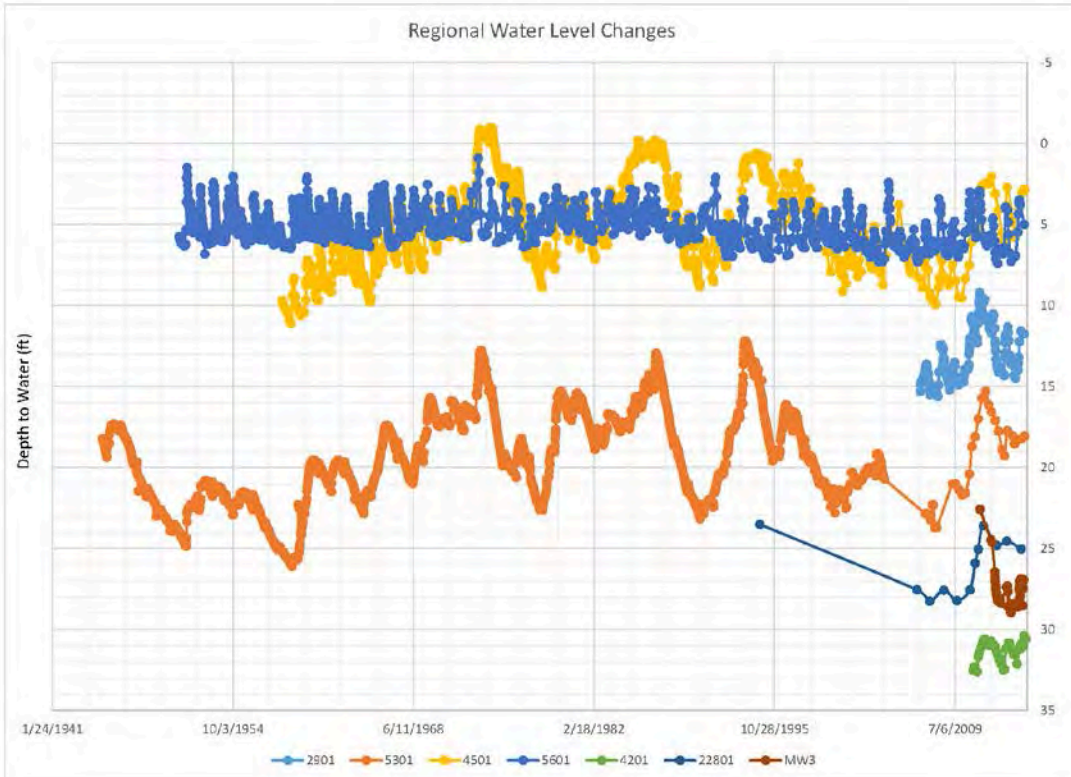


Figure 3: Depth to Water in USGS Monitoring wells and MW3

Table 1 summarizes the range in water levels in the USGS monitoring wells and the four City monitoring wells closest to Well 11. Groundwater levels vary by between 2.23 to 13.91 feet in the USGS monitoring wells with an average of 7.35 feet. The City monitoring wells near Well 11 had a range in water levels of 3.22 to 6.63 feet with an average of 5.3 feet. The historic data indicates that water levels in the aquifer near Well 11 actually have slightly lower variation than is typical for the aquifer on a regional basis.

Summary of Water Level Variations in Sand and Gravel Aquifer

	2901	5301	1601	4501	5601	4201	22901	MW3	MW4	MW7	MW8
Start	11/15/2006	11/17/1944	9/14/1994	7/2/1958	9/7/1950	11/17/2010	9/14/1994	5/23/2011	5/23/2011	5/23/2011	5/23/2011
Last	9/29/2014	10/15/2014	10/16/2014	10/16/2014	9/29/2014	11/17/2014	7/9/2014	9/12/2014	9/12/2014	9/12/2014	9/12/2014
max	15.60	26.09	51.22	11.09	7.40	32.60	28.24	28.95	33.61	25.19	33.72
min	9.20	12.18	45.62	-1.01	0.88	30.37	23.50	22.56	26.98	20.25	30.50
range	6.40	13.91	5.60	12.10	6.52	2.23	4.74	6.39	6.63	4.94	3.22

Table 1: Summary of Groundwater level variation over time

Figure 4 is a plot of the depth to water for the USGS monitoring wells, Well 11, and the three closest City monitoring wells to Well 11 for the last five years. Groundwater levels gradually increased by about three to five feet in all wells from early 2010 through the end of 2012. Water levels in all wells began to decline in the spring of 2012, coincidentally about the time Well 11 began pumping. However, the decline in water levels occurred in all wells, even though the USGS wells are well beyond the limits of any potential pumping effects of Well 11. The data shows the decline in water levels was regional in nature and was not specific to the area around Well 11.

Groundwater levels generally declined throughout 2012 and recovered quickly in the spring of 2013. The decline in groundwater levels seen in the City monitoring wells near Well 11 looks very similar to the declines observed in several USGS monitoring wells including USGS MW2901 and USGS MW5601. USGS MW5301 and USGS MW4501 showed similar magnitudes of variation but the measurement frequency was lower so it is not known if the rate of decline was similar to the City monitoring wells.

USGS MW2901 is approximately 7 miles south of Well 11. USGS MW5601 is approximately 15 miles south of Well 11. Both of these wells are in areas dominated by irrigated agriculture. USGS MW5301 is located approximately 15 miles north of Well 11 in an area dominated by forest land. USGS MW4501 is located approximately ten miles southeast in an area of mixed forest and agriculture. The data suggests that the changes in groundwater levels were regional in extent and were independent of land use suggesting that the cause was a change in recharge rather than an increase in pumping.

The MARS report relied on the Palmer Drought Severity Index to suggest that 2012 was a normal groundwater year. The Palmer Drought Index is primarily based on soil moisture. This is more indicative of growing conditions for plants and not a direct indicator of groundwater recharge or groundwater levels. The water level data from the monitoring wells clearly indicates groundwater levels were declining on a regional basis in 2012 despite the Palmer Drought Index showing that soil moisture was only slightly below average for the year. Direct groundwater level measurements are a much more reliable indicator of groundwater recharge conditions than the Palmer Drought Index.

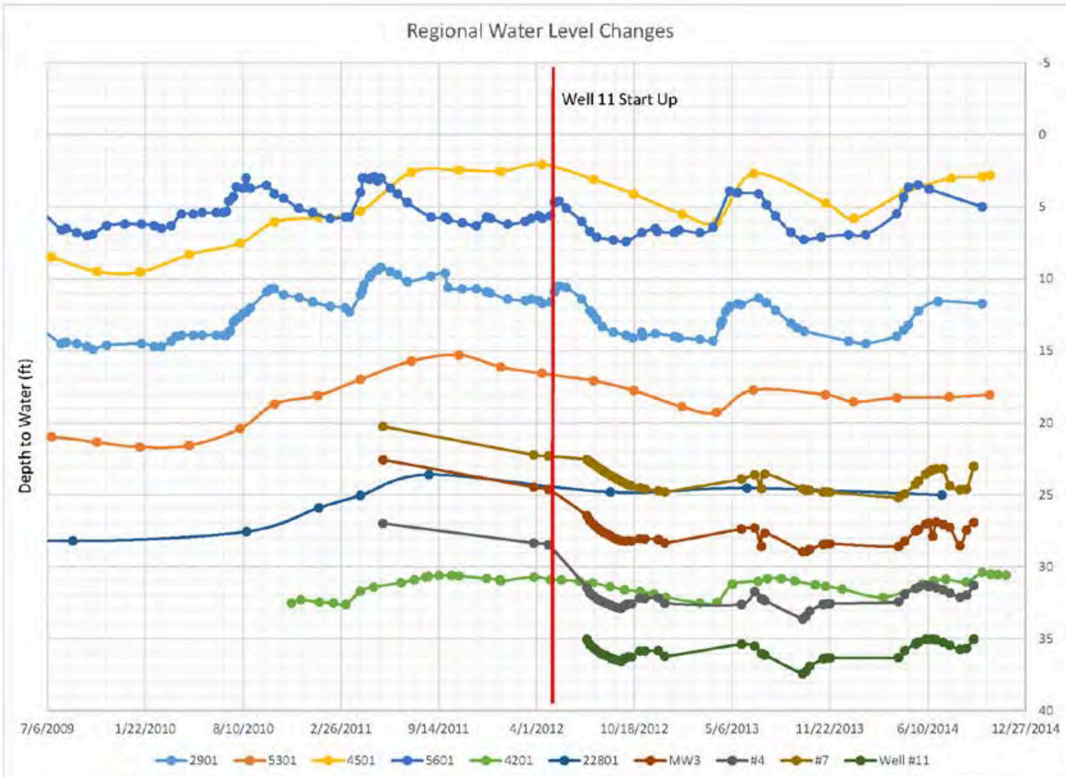
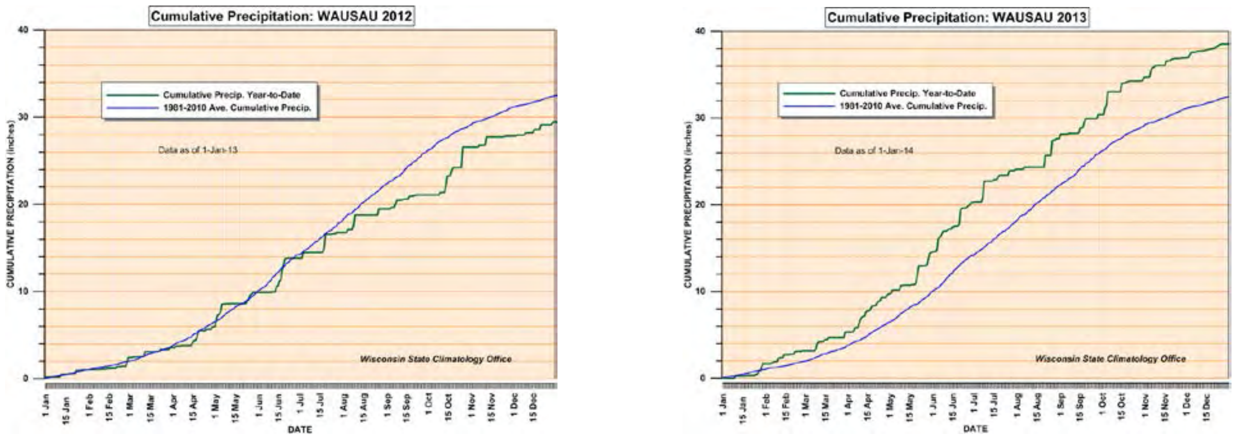


Figure 4: Plot of Changes in Ground Water Levels for the Last 5 years

Figure 5 shows the cumulative precipitation plotted against the normal precipitation for 2012 and 2013 at a weather station in Wausau, Wisconsin. The data demonstrates that the summer and fall of 2012 were abnormally dry.

Precipitation dropped below normal levels in June and trended below normal levels for the remainder of the year. Precipitation recovered to above normal in early 2013 and remained above normal for the rest of 2013. These observations suggest that the regional decrease in water levels in the summer and fall of 2012 were a natural response to a hot, dry summer. The rapid rise in water levels in the spring of 2013 was due to heavier than normal winter precipitation that generated a strong groundwater recharge event during the spring snow melt and heavier than normal precipitation for the rest of 2013.



http://www.aos.wisc.edu/~sco/clim-history/stations/auw/auw-rts-2012.gif

Figure 5: Cummulative Precipitation Vs. Normal Precipitation for 2012 and 2013 in Wausau, Wisconsin

Estimated Groundwater Level Impacts from Well 11

While there clearly was a regional drop in groundwater levels in 2012, that is not to say there were no local changes in groundwater levels from Well 11. The challenge is to isolate the impacts from a single well from multiple other factors such as seasonal and annual variations in recharge and variations in pumping rates from other wells. Such estimates are often made with little field data and rely on calculations based on assumptions about the aquifer. These estimates are only as reliable as the estimates used for the calculations and the ability to identify and account for all variables affecting the area. The track record of these methods is mixed depending on the rigor of the analysis and how complete and accurate the input data is.

In general, the most rigorous predictions are not as reliable as field measurements for the period of concern. Fortunately, the City of Stevens Point and the USGS have been collecting reliable field measurements of groundwater levels on a local and regional basis. This data allows more reliable estimates to be made for the impacts of a single well in comparison to the cumulative impact of other factors.

Figure 6 is a plot of the change in groundwater level since the startup of Well 11 for MW3 and the closest USGS monitoring well, USGS MW2901. The plot was calculated by setting the water level in each well from March 2012 to 0 and plotting the rise or decline in subsequent readings.

The maximum change in groundwater levels in MW3 since Well 11 started pumping is about 4 feet. This represents the maximum impact that could be attributed to Well 11 if there were no other factors affecting water levels in the aquifer. However, the regional water level shows that water levels declines of a similar magnitude were occurring throughout the aquifer over an area of miles around the well during the same time period. This indicates that a significant portion of the observed decline in water levels around Well 11 was due to regional factors and the actual impact is significantly less than 4 feet.

The plot also shows that the changes in groundwater levels in the two wells generally track each other from the point of startup of Well 11with the exception of a downward bias of about one to two feet in MW3. This is direct physical evidence that the groundwater levels around MW3 were one to two feet lower than expected. Most of this difference is probably due to pumping at Well 11. While simplistic, this estimate is based on field data and is more reliable than estimated values. Changes much lower than this magnitude are difficult to detect or accurately measure. Based on the available data, it is my opinion that the drawdown in the aquifer at MW3 caused by Well 11after pumping 2.8 mgd for over two years was clearly less than 4 feet, most probably less than 2 feet, and could be on the order of one foot. Drawdown from a pumping well declines logarithmically with distance from the well. The magnitude of drawdown from Well 11 would be substantially less beyond MW3 farther from Well 11.

With any of these estimates the change in the saturated thickness of the aquifer at MW3 is on the order of 1% to 5%, and much less in the area of most of the wells in question that are farther from Well 11. The drawdown from Well 11 in the area of concern is much less than the normal range of variation in the aquifer and small enough that it is difficult to measure. It is a small percentage of the available thickness of the aquifer and not enough to limit the ability of a home owner to obtain water from a reasonably well constructed well.

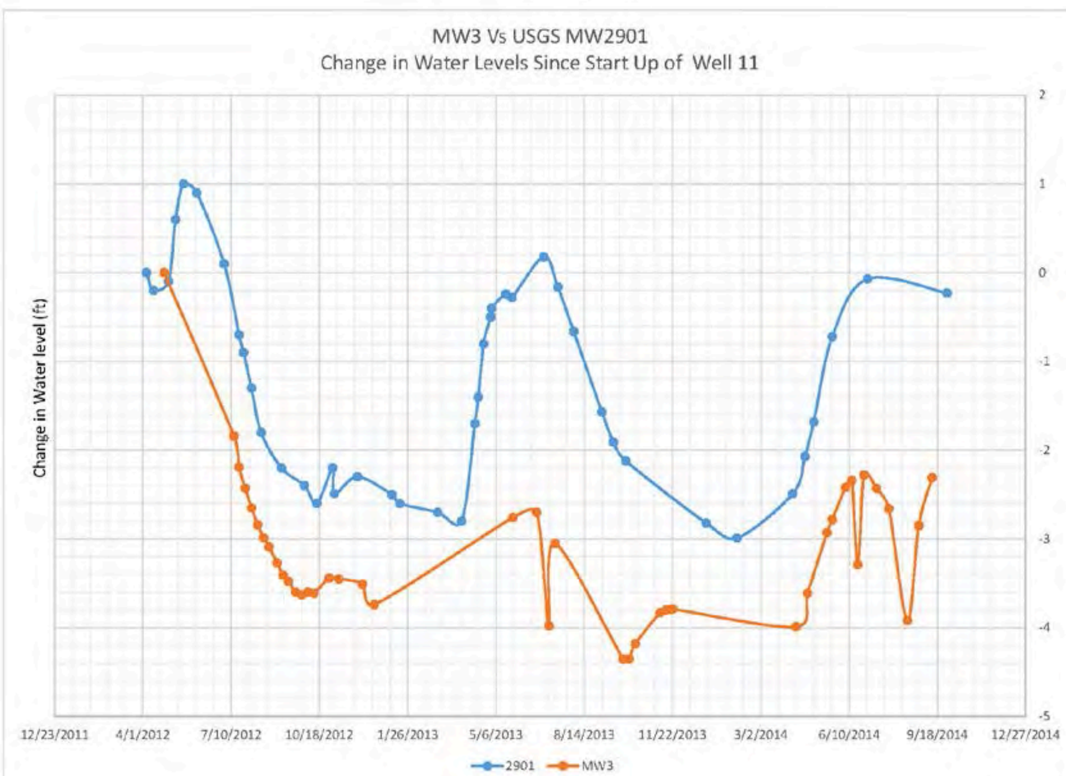


Figure 6: Change in Water Level of USGS MW2901 vs. MW3 Since Well 11 Start Up

The MARS report predicted drawdown from Well 11 at MW3 of between 2.5 and 6.5 feet using a Theis analysis and a regional groundwater model prepared by the University of Wisconsin Stevens Point Center for Watershed Science and Education (UWSP) for the Central Sands region.

The UWSP model was modified to incorporate a finer grid around Well 11 but the aquifer properties were not modified from the regional model. The regional model assumed an aquifer transmissivity value of about 60,000 gpd/ft in the area of Well 11, which is an average regional value. Aquifer testing conducted for Well 11 determined the actual aquifer transmissivity in the area was approximately 400,000 gpd/ft. The UWSP model overestimated the drawdown from well 11 because it used a regional transmissvity value for the aquifer that was not representative of the actual field conditions in the area. As a result the estimated drawdown of 6.5 feet at MW3 exceeds the maximum change in water levels observed, does not reflect local aquifer conditions, and is not a reliable estimate. This explains why their projected drawdown exceeds the maximum observed water level change in the aquifer by over 50% and is substantially higher than the measured drawdown when corrected for regional water level changes. Additional model calibration would be required to modify the model to the point that it could produce more accurate estimates of drawdown in the aquifer around Well 11.

MARS also estimated drawdown at MW3 using the Theis equation, a standard method of predicting drawdown at various times and distances from a pumping well. Their analysis predicted a drawdown of 2.5 feet at MW3 after 2 years of pumping, which is close to the upper bound of my estimate of one to 2 feet based on the monitoring well data. The Theis method is a valid and well proven method but it requires several simplifying assumptions to make the calculations. The method assumes no recharge to the aquifer and no regional flow in the aquifer, among some other assumptions. While neither of these assumptions is strictly true for any aquifer, and certainly not true for this aquifer, the results of the analysis are generally useful if the limitations created by these assumptions are taken into account when conducting analysis.

The fact that the aquifer around Well 11 receives local recharge and has a regional flow component means that the pumping stress from the well will stabilize when the cone of depression around the well expands enough to capture enough recharge and regional flow to replace the water being pumped. At that point, the aquifer will reach a new stable condition and the cone of depression will cease to expand unless the pumping rate or amount of recharge changes. The time required to reach a stable steady state condition varies based on the aquifer and pumping rate, but it is typically on the order of a few days to a few weeks for permeable aquifers that receive ample recharge.

Figures 4 and 6 show that water levels in the City monitoring wells had all stabilized and begun to recover within a few months of the startup of Well 11. While much of the drawdown was caused by dry conditions and the recovery was due to a return to more normal precipitation patterns the data does show that the aquifer was not continuing to decline due to pumping at Well 11 after a few months at longest. With this in mind, we believe that drawdown prediction from the Theis analysis should have been cut off after a few months and the predicted drawdown at MW3 should have been on the order of 1 to 1.5 feet, which is consistent with my estimate from the monitoring well data.

Discussion of Significance of Projected Impacts

In my opinion the available data indicates the range of groundwater level impacts from Well 11 at MW3 is on the order of 1 to 2 feet. Drawdown in the aquifer from Well 11 is lower farther away from Well 11. This is slightly less than the lower range estimate provided by MARS but the magnitude of the difference is small and insignificant when viewed in terms of the natural range in variations in the aquifer.

According to the Town, most of the wells that reported problems were sand points that only penetrated a short distance into the saturated part of the aquifer indicating these wells were highly vulnerable to changes in water level or increases in drawdown from their own pumping. The condition of a well deteriorates over time due to plugging of the screen from mineral encrustation or biological fouling. The drawdown inside a well typically increases over time as a greater head difference is needed to draw water through a plugged screen. It is common for a well to lose capacity as over time and this process is especially significant for small diameter wells with short screens completed a short distance into the aquifer such as the sand points in question. These wells were vulnerable to small fluctuations in groundwater levels and were likely to fail eventually, especially in a dry year.

2012 had a dry summer and fall and water levels declined several feet on a regional basis in response to the reduction in recharge to the aquifer. Typically there is a significant increase in outdoor water use in dry years to water lawns, gardens and landscaping. It is likely that the affected wells, or wells on adjacent properties, were pumping more than normal in 2012 and created more drawdown in and around the wells. The combination of heavier water use and declining water levels from reduced recharge were much larger contributing factors to the failure of the wells than pumping from Well 11. This is even more apparent when the pattern of failed wells is compared to the proximity of Well 11. Wells nearly a mile from Well 11 failed, a distance where the impact of pumping from Well 11 was negligible.

Considering the probable range of drawdown from Well 11 on the affected wells in comparison to the decline in groundwater levels due to the dry conditions and the construction and condition of the wells, Well 11 had at most a minor role in the failure of these wells. The primary cause of the failure of these wells was the construction and condition of the wells in combination of a regional decline in water levels due to a dry summer. These wells would not have experienced an interruption in service had they been constructed deeper into the aquifer. In my opinion, the failure of these wells was not the fault of the City of Stevens Point.

I trust this information is useful in your deliberations on this matter. Please remember that the opinions rendered in this report are based on the information available to me at the time of analysis. Please let us know if we can answer any questions or provide more information.

Very truly yours,

LEGGETTE, BRASHEARS & GRAHAM, INC.

John Jansen
Senior Associate